

Amendments to the Specification:

Please replace the paragraph, beginning at pages 12-13, line 2, with the following rewritten paragraph:

FIG 1B is a flow diagram that depicts the flow scheme of the present invention in a heating mode for the phase separator 50 and the reaction vessel 110, which contains the isothermal mixing baffle(s) 400 and the helical channel coil 100 fixed to the outer surface of reaction vessel 110. In a preferred embodiment the helical channel coil 100 may also extend to cover the upper head 112 and lower head 113 of reaction vessel 110. High "quality" (mostly vapor content) working fluid shown in line 30 enters the phase separator 50 and is split into a vapor phase shown by line 13 and a liquid phase shown by line 11, the separation effected by gravitational means. The vapor phase 13 from the phase separator 50 is piped to the isothermal mixing baffle(s) 400, wherein it changes into a liquid by condensing and delivering thermal energy to the content inside the reaction vessel 110. The liquid 11 emanating from the phase separator 50 is commingled with the condensate in line 32 generated in the isothermal mixing baffle(s) 400 in a separate mixing chamber 60₃₄. The now combined liquid streams in line 36 are fed into the channel coil 100, wherein the liquid delivers sensible thermal energy to the content inside the reaction vessel 110 until it exits the channel coil in line 15 at a temperature very close to that of the average temperature of the reactor content.

Please replace the paragraph, beginning at page 13, line 5, with the following rewritten paragraph:

FIG. 2 A is a cross-sectional view of a reaction vessel 110 with a channel coil 100 fixed to the outer surface in a helical wound arrangement. In a preferred embodiment, the reaction vessel 110 consists of a cylindrical section 111₁₂₀ and two "dished" heads, an upper head 112 and a lower head 113. The inside wall of channel coil 100 is the outside surface of wall 120 of reaction vessel 110 and will be disposed along the axial length of the cylindrical section 111₁₂₀ of reaction vessel 110. The channel coil 100 may also cover part of the upper head 112 and/or the lower head 113. The channel coil 100, before it is fixed to the reaction vessel 110, has only three outer sides, 121, 122, and 123. A fourth side of the channel coil 100 is formed by the outer surface of the wall of cylindrical section 120 of the reaction vessel 110. A closed channel is only achieved when the channel coil 100 is fixed to the outer surface of reaction vessel 110. The channel coil 100 surrounds the reaction vessel 110 in a helical configuration. The configuration allows for helical and corresponding downward or upward flow, with respect to the central vertical axis of the reaction vessel 110. The channel coil 100 may be constructed from any suitable material, the most likely for industrial use being carbon steel, stainless steel, Inconel (trademark for an alloy of nickel and chromium available from the Huntington Alloy Products Division of International Nickel Co. Inc. of Huntington, West Virginia), and any number of Hastelloy alloys, including Hastelloy C-276 and Hastelloy B-2. Hastelloy is a trademark for nickel-based corrosion-resistant alloys obtained from Union Carbide Corp. of New York, New York. Hastelloy C-276 is a nickel-based alloy containing nickel, chromium, molybdenum, tungsten, iron, carbon and silicon. Hastelloy B-2 differs from Hastelloy C-276 in that it does not contain tungsten and the other components appear in different concentrations.

Please replace the paragraph, beginning at page 13, line 30, with the following rewritten paragraph:

In an alternate embodiment, the cylindrical section 111-120 of reaction vessel 110 can be replaced with a conical section 114 having a wall 125 and two "dished" heads, a larger upper head 115 and a smaller lower head 116 as shown in FIG. 2B. This alternate embodiment allows for better mixing of the contents and is advantageous in applications where gaseous reaction by-products are generated in the reaction vessel content.

Please replace the paragraph, beginning at page 14, line 13, with the following rewritten paragraph:

FIG. 3A is a cross-sectional view of the cylindrical reaction vessel 110 of with integral channel coil 100 and integral isothermal mixing baffle 400 (one only shown for simplicity). FIG. 3B is a cross-sectional view of an conical reactor 114 with integral channel coil 100 and integral isothermal mixing baffle 400 (one only shown for simplicity). FIG. 2A, FIG 2B, FIG. 3A and FIG. 3B show two characteristics of channel coil 100, which combine to add mechanical strength to reaction vessel 110. The first is that the point of contact 130, 131 is a right angle to the reaction vessel wall 120, 125 respectively in the vertical section of the reaction vessel 110 or the tapered wall section of conical reactor 114, as well in the upper heads 112, 115 and lower heads 113, 116 respectively. That is, walls 121 and 123 form a right angle with walls 120 and 125. In the preferred embodiment shown in FIG. 1A and 3A, walls 121 and 123 must form a right angle with the axis of the cylinder reaction vessel 110 having a vertical cylindrical section where the channel coil is fixed to the wall 120. In the upper 112 and lower 113 head sections of the reaction vessel 110, walls 121 and 123 are perpendicular to the line tangent to the convex (external) surface of the head, 112 or 113, where the tangent point is at the bisector between 121 and 123. The channel coil 100 surrounding wall 120 of vessel 110 and wall 125 of vessel 114 can be covered with insulation 700.

Please replace the paragraph, beginning at pages 14-16, line 31, with the following rewritten paragraph:

The same effect is achieved for the reaction vessels of FIG. 2B and 3B where the vertical section has cone shape wall 125 by fixing portions 121 and 123 perpendicular to wall 125. The perpendicularity of portion 121 and 123 of channel coil 100 to wall 120 or wall 125 of the reaction vessel 110 or 114 is required in order to meet the criteria established by section UG-28 of the ASME Boiler And Pressure Vessel Code Section VIII Division 1 so that elements 121, 122 and 123 can be considered as adding strength to the wall 120 under external pressure. The second characteristic adding strength to reaction vessel 110 concerns the pitch at which the helical channel coil 100 is affixed to the reaction vessel wall 120. For the vertical portion (cylindrical or tapered wall) of the reaction vessel 110 or 114, the pitch is the slope of the coil 100, with respect to a horizontal radial plane which is perpendicular to the vertical axis of the reactor. A larger slope is considered a higher pitch. The channel coil 100 is affixed at a pitch less than or equal to a maximum pitch, which is that pitch beyond which the desired improvements in the reaction vessel wall 120, 125 section modulus are no longer achieved, as dictated by the rules of pressure vessel design codes such as ASME Section VIII, Division 1, sections UG-27 and UG-28 thereof. Section UG-27 explains how to calculate "Thickness of Shells Under Internal Pressure", and section UG-28 describes how to calculate "Thickness of Shells and Tubes Under External Pressure". Exactly what this pitch is will depend on many factors. As to reaction vessel 110 or 125 114 these include the diameter of reaction vessel 110, the average diameter of vessel 114, the material of construction of the reaction vessel and the operating parameters for which the reactor is designed. As the pitch (or slope) of the coil increases, the distance between successive coils increases. The coil is made of elements 121

and 123 that are perpendicular to the vessel wall, 120, 125 which allows for the vessel, under the rules of pressure vessel design codes such as ASME Section VIII, Division 1 to take credit for the reinforcement to reaction vessel wall 120, 125. As the distance between successive coils increases the degree of reinforcement decreases. At some point, the degree of reinforcement becomes too low and reaction vessel wall 120, 125 becomes too weak for the desired function. The reinforcement required will depend upon the differential pressure between the inside and outside of reaction vessel wall 120, 125. This is a design parameter easily calculated by one skilled in the art. Thus, the maximum pitch of channel coil 100 will depend on the designed maximum operating pressure for reaction vessel 110, 114 among other factors. For example for the head sections 112, 113 of the reaction vessel 110, the pitch is the distance of each helical 360° course of the coil 100, with respect to the previous and/or subsequent helical 360° course. A greater separation is considered a higher pitch. The channel coil 100 is fixed at a pitch less than or equal to a maximum pitch, which is that pitch beyond which the desired improvements in the reaction vessel wall 120 section modulus are no longer achieved, as dictated by the rules of pressure vessel design codes such as ASME Section VIII, Division 1, sections UG-27 and UG-28 thereof. Section UG-27 explains how to calculate "Thickness of Shells Under Internal Pressure", and section UG-28 describes how to calculate "Thickness of Shells and Tubes Under External Pressure". Exactly what this pitch is will depend on many factors including the diameter of reaction vessel 110, the material of construction of the reaction vessel 110 and the operating parameters for which the reactor is designed. As the pitch (separation) of the coil 100 fixed to the upper or lower heads 112 and 113 of reaction vessel 110 increases, the distance between successive coils increases.

Please replace the paragraph, beginning at page 16, line 16, with the following rewritten paragraph:

The point of contact 130 between reaction vessel wall 120 and channel coil 100 of reaction vessel 110 and the point of contact 131 between reactor vessel wall 125 and channel coil 100 of reactor vessel 114 (FIG. 2A, 3A and FIG. 2B, 3B respectively) is a right angle, and the pitch of the channel coil 100 is less than or equal to the maximum pitch. These two factors combine to increase the section modulus of the reaction vessel 110. Under the rules of pressure vessel design codes such as ASME Section VIII, Division 1, section UG-28 thereof this resultant increase in the section modulus, due to the channel coil 100, allows the reaction vessel wall 120 be thinner than that which would otherwise be required when the channel coil 100 is not fixed according to the present invention in order to achieve desire maximum allowable pressure for reaction vessel working conditions. Because the reaction vessel wall 120 may be thinner than that which would be required without channel coil 100, improved heat transfer efficiency is achieved. A thinner reaction vessel wall increases the overall heat transfer coefficient across the reaction vessel wall because the thermal resistance resulting from the thermal conductivity of the reaction vessel wall is reduced. Under the rules of pressure vessel design codes such as ASME Section VIII, Division 1, the greatest advantage of the present invention is realized in larger diameter reaction vessels that operate at relatively low pressures, e.g., up to 10 bar and at full vacuum (FV). Under these conditions, the FV condition inside the reaction vessel dictates the use of thicker wall 120, 125 than otherwise be required to withstand positive internal pressure only. By using the present invention, the wall thickness of wall 120, 125 is controlled by positive internal pressure in the reaction vessel and will be thinner.

Please replace the paragraph, beginning at page 19, line 15, with the following rewritten paragraph:

For instance, if a higher rate of cooling is desired, then fluid flow into the isothermal mixing baffle 400 can be increased. This will raise the level of boiling liquid 450 to a level shown as 448-451 in FIG. 5A in the isothermal mixing baffle 400. This in turn will expose a greater surface area of boiling liquid 450 to wall 449 of isothermal mixing baffle 400, thus allowing greater heat transfer from the reaction vessel contents through wall 449 of baffle 400 into boiling liquid 450.

Please replace the paragraph, beginning at page 19, line 24, with the following rewritten paragraph:

The ideal temperature (or range of temperatures) of the reaction vessel contents can be determined from the chemistry of the reaction. This temperature, along with the physical characteristics of the isothermal mixing baffle (dimensions, material of construction, number of baffles, etc.) and relevant heat transfer equations, are combined to give rise to a required amount of heat transfer which must occur across the wall 449 (FIGS. 5A, 5B, 5C, and 5D) of the isothermal mixing baffle 400 in order to maintain the reactor contents at the desired temperature. From this required value of heat transfer, a fluid is selected such that the latent heat of vaporization plus any sensible heat transfer occurring from any rise in temperature of the fluid to its boiling point, will give the desired total heat transfer. It should be noted that a fluid with precisely the right characteristics does not have to exist for accurate control of the temperature. Controlling the flow rate of the fluid into the isothermal mixing baffle 400 or the liquid level thereof will allow for fine tuning the heat transfer and corresponding temperature of the reactor contents. Further, controlling the pressure of the liquid could help alter its boiling point and fine tune the cooling power and range of the liquid. The selected fluid need only fall within a range of necessary heat transfer requirements. Where heating is desired, as shown in FIG 1B, a hot gas, such as gaseous ammonia, is introduced via line 13 into isothermal mixing baffle 400, the condensed ammonia in line 32 is then combined with other condensed ammonia in line 11 emanating from the phase separator 50 and introduced via line 36 into the channel coil 100. This hot gas and resultant condensate then heats the contents of reaction vessel 110.

Please replace the paragraph, beginning at page 20, line 12, with the following rewritten paragraph:

In cooling applications, the isothermal mixing baffles 400 are designed and arranged in so that their combined cross-sectional area will be such that the velocity of the vapor evolved from the liquid phase boiling therein will be below a critical value, U_c , above which droplets or slugs of the liquid phase will be entrained in the evolved gas and expelled from the isothermal mixing baffles. As shown in FIGs. 5A, 5B, 5C, and 5D in order to accomplish this requirement, the saturated or sub-cooled inlets 420-410 and vapor outlets 430 of the isothermal mixing baffles 400 will be piped in parallel. Discrete cooling control can be accomplished by isolating individual isothermal mixing baffles from the plurality of isothermal mixing baffles piped in parallel.

Please replace the paragraph, beginning at page 24, line 20, with the following rewritten paragraph:

FIG. 8A and 8B show additional embodiments of the cross-sectional shape of channel coil 100. The outside walls 100, 102 of the channel coil 100 may be of nearly any shape. It is critical, however, that the portion of 100, 102, adjacent wall 120 of vessel 110 shown as walls 701, 702 (FIG. 8A) and 703, 704 (FIG. 8B) are both normal to the outside reaction vessel wall 120. In

this configuration, channel coil 100 supports and strengthens reaction vessel wall 120, allowing use of a thinner wall and greater heat transfer.

Please replace the paragraph, beginning at pages 24-25, line 22, with the following rewritten paragraph:

FIG. 10 is a cross-sectional view of a preferred embodiment of phase separator 50 having an internal vessel 59 and an evacuated shell 57 of the present invention for use in a cooling or heating mode application. The evacuated shell 57-59 completely encloses internal vessel 59 57, with the exception of related piping and utilities, which penetrate the evacuated shell 57-59. The placement of the evacuated shell 57-59 around the apparatus as described above allows for additional insulation of internal vessel from the ambient air. Insulation from the ambient air results in decreased heat transfer through the internal vessel 59-57, as some of the energy is parasitically lost outwardly to the environment through the insulation 58. The utilization of evacuated shell 57-59 results in greater temperature control of the reaction vessel contents, making the insulation 58 more thermally efficient. The evacuated shell 57-59 may be constructed from any suitable material, including carbon steel, stainless steel, Inconel, or Hastelloy C. Further, evacuated shell 57-59 can also include reflective material on the inner or outer surface thereof to reduce radiant heat transfer.

Please replace the paragraph, beginning at page 25, line 4, with the following rewritten paragraph:

FIG. 9A and 9B are alternative embodiments of FIG. 5A and 5B, respectively, wherein the wall 449-a 449a comprises cylindrical sections of different diameters so that the smaller diameter accommodates the trajectory of agitator blades and the larger diameter allows for greater heat transfer area.

Please replace the paragraph, beginning at page 25, line 6, with the following rewritten paragraph:

Working heat transfer fluid which may be sub-cooled, saturated or contain both phases enters the phase separator at the inlet nozzle 10 and is ducted vertically through an internal coaxial pipe 51 to a porous membrane diffuser 52 through which it enters the internal phase separator vessel 59-57.

Please replace the paragraph, beginning at page 25, line 9, with the following rewritten paragraph:

In order for the liquid and vapor phases of the working heat transfer fluid to separate by gravity, the cross-sectional area of the internal vessel 59-57 of phase separator 50 will be such that the velocity of the vapor separated from the liquid phase entrained therein will be below a critical value, U_c , above which droplets or slugs of the liquid phase will be entrained in the evolved gas and expelled from the phase separator.

Please replace the paragraph, beginning at page 25, line 16, with the following rewritten paragraph:

The liquid phase of the working heat transfer fluid enters the annulus between the external coaxial pipe 55 and the internal coaxial pipe 51 through apertures 56 on the external coaxial

pipe 55 located at the lower end of the internal vessel 59_57. The liquid phase of the working heat transfer fluid then exits the phase separator at the outlet liquid nozzle 11. The vapor phase of the working heat transfer fluid then exits the phase separator at the outlet vapor nozzle 13.

In view of the amendments to the specification applicant will, if requested, provide a complete clean copy of the specification without editing notations.

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ECG-100US

Amendments to the Drawings:

Please approve amendments to Figures 3B, 4, 5A, 5B, 5C, 5D, 5E, 5F, 6A, 7A, 7B, 9A, 9B, 10 and 11 detailed in the red-inked sketch enclosed with this amendment.